M. L. V. Textile & Engineering College, Bhilwara

Sub: WC MID TERM- (2017-18) 7^{Th} sem ECE

Ques 1. Write the relative advantages of spread-spectrum technique and different modulation scheme to achieve it. (5)

Ans. Advantages Of Spread-Spectrum Technique

1. Robustness against narrow band interference
2. Relatively high security
3. Coexistence of several signals – the receiver can separate each user based on code
4. No need of frequency planning as all user uses same BW
5. Wide band signals – less prone to interference, less prone to fading

Classification Different Modulation Scheme

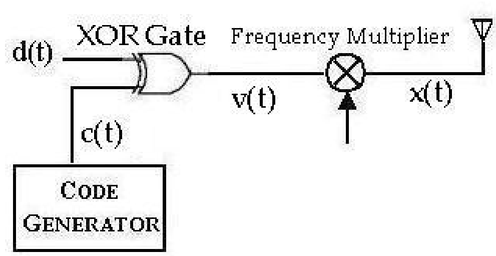
1. Direct Sequence (DS) SS Systems
2. Frequency Hopping (FH) SS Systems

1. Direct Sequence (DS) SS Systems

Bandwidth spreading by direct modulation of signals by a wideband spread signal (also called code) is called direct sequence spread spectrum (DS SS). The DSSS signal is then modulated by a carrier before final transmission. In DSSS, the base band signals are usually called bits, and the code bits are called chips. Typically, the baseband signal bandwidth is multiplies several times by the spreading signals. In other words, the chip rate is much higher than the bit rate. The spreading signal sequence is unique for a transmitter, and the same chip sequence is used at the receiver to re-construct the signals (data bits). A mechanism, by name correlation is used to synchronize the received spread signals (that contain data) with the locally generated code. At maximum received signal strength, correlation said to have occurred. The receiver then enters the tracking mode, such that the spread signal modulated signals are received without interruption.

A simple DSSS system is described below:

1. DSSS Transmitter:



Where,

d(t) is the input data bits

c(t) is the code bits

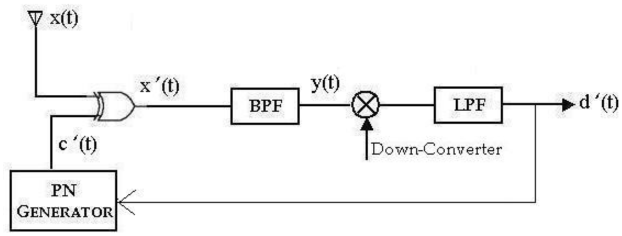
x(t) is the frequency converted signal, ready for transmission.

A note about why frequency up conversion is required for radio transmission: Base band, and very low frequencies are susceptible to heavy attenuation during transmission. In addition, imagine every transmitter transmitting in the base band frequencies. It is practically impossible for everyone to transmit in base band frequencies (A base band frequency is the frequency spectrum that is occupied by the unmodulated signals). Hence up-conversion of frequency is normally done to comply with the transmission requirements.

In the DSSS transmitter, a code generator is a pseudo random generator that generates a known pseudo noise code sequence. Normally, the code has finite length (say 1024 chips), and repeats periodically.

DSSS receiver:

A simplified DS SS receiver block diagram is shown below.



It consists of a PN generator that feeds the matching chip sequence to an XOR gate to reproduce the original bit sequence. The PN generator is driven by an error signal from the output of the LPF, so that chip timing is adjusted to produce maximum signal threshold. Normally, the acquisition of the data is done through a two step process. The first is acquisition, and the second is tracking. Acquisition refers to acquiring the chip timing of the received signals. This may further be sub-divided into course acquisition, and fine acquisition. The two are differentiated by the amount of chip timing adjustment. Once the acquisition is achieved, then the received signals must be tracked properly. Otherwise, you may loose the lock, resulting in loss of data bits. As with conventional receiver operation, an error voltage at the output of the LPF (or an Integrator) provides necessary correction to the PN Generator.

3. Pseudo Noise Codes (PN Codes): The PN codes used for DSSS require certain mathematical properties.

1. Maximum Length Sequences: These are PN sequences that repeat every 2^n -1, where n is an integer. These sequences can be implemented using shift registers. The PN sequences must exhibit good correlation properties. Two such sequences are Barker Codes, and Willard Codes.

2. Maximum Auto-Correlation: When the received signal is mixed with locally generated PN sequence, it must result in maximum signal strength at the point of synchronization.

3. Minimum Cross-Correlation: When the received signal with a different PN sequence than that of the receiver, is mixed with the locally generated PN sequence, it must result in minimum signal strength. This would enable a DSSS receiver to receive only the signal matching the PN code. This property is known as Orthogonality of PN Sequences.

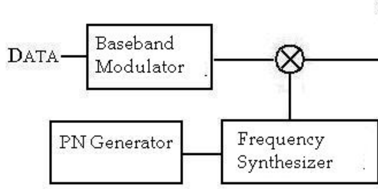
Frequency Hopping (FH) SS Systems:

Here the transmitted signal appears as a data modulated carrier which is hopping from one frequency to next, and therefore, it is called frequency hopping spread spectrum (FH-SS). FH systems work by driving a frequency synthesizer with pseudorandom sequence of numbers that result in the synthesizer hopping different frequencies at different points, and thus achieving signal spread. At the receiver end, the same principle works. A synthesizer is driven by a matching code to achieve maximum threshold detection of received signals.

A simplified block schematic of a FH SS system is shown below:

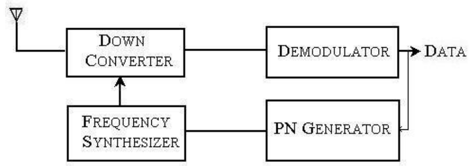
1. FH-SS Transmitter:

The transmitter consists of a baseband modulator followed by frequency synthesizer. The frequency synthesizer is driven by a PN generator. A PN generator may be built internal to the synthesizer.



2. FH-SS Receiver:

A FH-SS receiver consists of a down converter followed by a demodulator. A synthesizer, driven by a matching PN generator is used to down convert the received signals. A miximum received signal threshold signifies locking.



Ques 2. What are Kepler's three laws of planetary motion? Give the mathematical formulation of Kepler's third law of planetary motion. What do the terms Perigee and Apogee mean when used to describe the orbit of a satellite orbiting the earth? (5)

Ans. Kepler's laws of planetary motion are three scientific laws describing the motion of planets around the Sun

1. The orbit of a planet is an ellipse with the Sun at one of the two foci.
2. A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time.[1]
3. The square of the orbital period of a planet is proportional to the cube of the semi-major axis of its orbit.

Third law of Kepler[edit]

The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit.

This captures the relationship between the distance of planets from the Sun, and their orbital periods.

Kepler enunciated in 1619[12] this third law in a laborious attempt to determine what he viewed as the "music of the spheres" according to precise laws, and express it in terms of musical notation.[17] So it was known as the harmonic law.[18]

Using Newton's Law of gravitation (published 1687), this relation can be found in the case of a circular orbit by setting the centripetal force equal to the gravitational force:

$$mr\omega^2 = G\frac{mM}{r^2}$$

Then, expressing the angular velocity in terms of the orbital period and then rearranging, we find Kepler's Third Law:

$$mr\left(\frac{2\pi}{T}\right)^2 = G\frac{mM}{r^2} \rightarrow T^2 = \left(\frac{4\pi^2}{GM}\right)r^3 \rightarrow T^2 \propto r^3$$

A more detailed derivation can be done with general elliptical orbits as well as the center of mass. This results in replacing a circular radius, , with the elliptical semi-major axis, , as well as replacing the large mass with . However, with planet masses being so much smaller than the sun, this correction is often ignored. The full corresponding formula is:

$$\frac{T^2}{a^3} = \frac{4\pi^2}{G(M+m)} \approx \frac{4\pi^2}{GM} = 7.495 * 10^{-6} \left[\frac{AU^3}{days^2}\right] = \text{constant}$$

where is the mass of the sun, is the mass of the planet, and is the gravitational constant, is the orbital period and is the elliptical semi-major axis.

Apogee and perigee refer to the distance from the Earth to the moon. Apogee is the farthest point from the earth. Perigee is the closest point to the earth and it is in this stage that the moon appears larger.

Ques 3. What is small scale fading? Write the factors influencing fading. (5)

Ans. small scale fading

Small scale fading or simply fading is used to describe the rapid fluctuations of the amplitudes, phases, or multi path delays of radio signal over a short period of time or travel distance, so that large scale path loss effects may be ignored.

1. Fading is caused by interference between two or more versions of the transmitted signal which arrive at receiver at slightly different times.
2. These waves are called as multipath waves combine at receiver antenna to give a resultant signal which can very widely in amplitude and phase, depending on distribution of the intensity and relative propagation time of waves and bandwidth of transmitted signal
    - Three most important small scale fading effects are: Rapid changes in signal strength over a small travel distance or time interval
    - Random frequency modulation due to varying Doppler’s shifts on multi path signals
    - Time dispersion (echoes) caused by multi path propagation delay.
3. For narrow band signal small scale Fading typically results in a Rayleigh fading distribution of signal strength over small distances. The signal fluctuates in a range of about 40dB (10 dB above and 40 dB below the average signal)
4. Microscopic diversity techniques can be used to prevent deep fades from occurring. For e.g.-If two antennas are separated by fraction of a meter, one may receive a null while the other receives a strong signal. By selecting the best signal at all times, a receiver can reduce small scale fading effects.
5. Factors influencing small scale fading :

A. Fast fading:

- A channel is classified as fast fading or slow fading depending upon how the transmitted signal changes as compared to the rate of change of the channel. In multipath component fast fading occurs due to speed of mobile terminal and bandwidth of the signal.
- In fast fading the channel impulse response changes rapidly within the symbol duration i.e. the coherence time of the channel is smaller than the symbol period of the transmitted signal.
- This causes frequency dispersion due to Doppler spreading which leads to signal distortion.
- In the frequency domain, signal distortion due to fading increases with increasing Doppler spread relative to the bandwidth of the transmitted signal. Therefore a signal undergoes fast fading if

  Ts> Tc and Bs <bd <="" p="">

  Ts= symbol period of transmitted signal,

Tc= coherence time of channel,

Bs=signal bandwidth,

BD= Doppler spread

Thus due to Doppler spreading the frequency dispersion or time selective fading occurs. - Fast fading only deals with the rate of change of channel due to motion. Fast fading channel is the channel in which the amplitude of the delta function varies faster than the rate of change of the transmitted baseband signal. - In case of frequency selective fast fading channel the amplitudes, phase and time delays of any of one of the multipath components vary faster than the rate of change of the transmitted signal. - Fast fading occurs for very low data rates.

B. Slow fading:

- In slow fading the channel impulse response changes at a rate much slower than the transmitted baseband signal. In this channel is assumed to be static over one or several bandwidth interval.
- In frequency domain in slow fading Doppler spread is much less than the bandwidth of the baseband signal. Thus the signal undergoes slow fading if

  Ts<< Tc and Bs >>BD

  Ts= symbol period of transmitted signal,

  Tc= coherence time of channel,

  Bs=baseband signal bandwidth,

  BD= Doppler spread.

- It occurs when the channel variations are slower than base station signal variation. If channel variations are less Doppler spread is less and thus slow fading takes place.

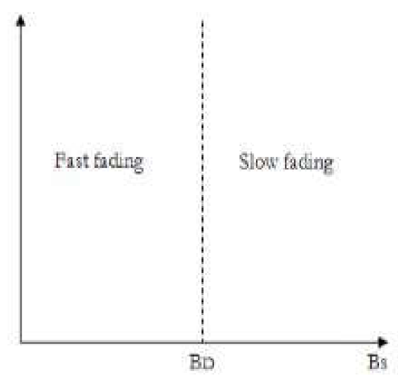


Fig: Matrix illustrating type of fading experienced by a signal as a function of baseband signal bandwidth

The factors influencing small scale fading are:

A. Multipath propagation:

- Reflecting objects and scattering in the channel creates a constantly changing environment that dissipates the signal energy in amplitude, phase and time. This results in multiple version of transmitted signal that arrive at the receiving antenna, displaced with respect to one another in time and space.
- The random phase and amplitude of the different multipath components cause fluctuations in signal strength causing small scale fading.
- Multipath propagation increase the time required for the baseband portion of signal to reach the receiver which cause signal smearing due to intersymbol interference.

B. Speed of mobile:

- The relative motion between the base station and the mobile results in random frequency modulation due to different Doppler shifts on each of the multipath components.
- Doppler shift is positive if mobile receiver is moving toward the base station and is negative if mobile receiver is moving away from the base station.

C. Surrounding of mobile:

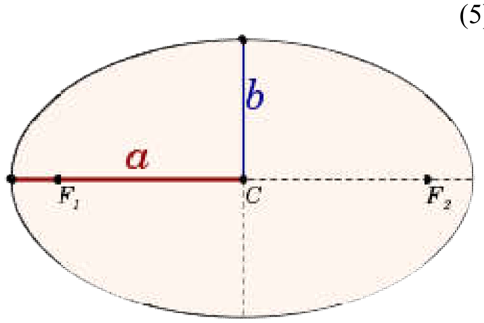
- If objects in the radio channel are in motion, they induce varying Doppler shift on multipath components.
- If the surrounding objects move at a greater rate than the mobile, then this effect dominates the small-scale fading. Otherwise motion of surrounding objects can be ignored.

D. Transmission bandwidth of signal:

- If transmitted radio signal bandwidth is greater than the bandwidth of the multipath channel, the received signal will be distorted but the received signal strength will not fade much over a local area.
- If transmitted radio signal bandwidth is less than the bandwidth of the multipath channel, the received signal will not be distorted but the received signal strength will change rapidly.
- Bandwidth of the channel is quantified by the coherence bandwidth which is related to specific multipath structure of the channel. Coherence bandwidth is measure of maximum frequency difference for which signals are strongly correlated in amplitude.

Ques 4. Explain the following terms with respect to satellite communication: Orbital period, orbital velocity, azimuth and elevation.

(5)



Ans. orbital period

The orbital period is the time a given astronomical object takes to complete one orbit around another object, and applies in astronomy usually to planets or asteroids orbiting the Sun, moons orbiting planets, exoplanets orbiting other stars, or binary stars.

For objects in the Solar System, this is often referred to as the sidereal period, determined by a 360° revolution of one celestial body around another, e.g. the Earth orbiting the Sun. The name sidereal is added as it implies that the object returns to the same position relative to the fixed stars projected in the sky. When describing orbits of binary stars, the orbital period is usually referred to as just the period

The orbital period is the time a given astronomical object takes to complete one orbit around another object, and applies in astronomy usually to planets or asteroids orbiting the Sun, moons orbiting planets, exoplanets orbiting other stars, or binary stars.

For objects in the Solar System, this is often referred to as the sidereal period, determined by a 360° revolution of one celestial body around another, e.g. the Earth orbiting the Sun. The name sidereal is added as it implies that the object returns to the same position relative to the fixed stars projected in the sky. When describing orbits of binary stars, the orbital period is usually referred to as just the period.

According to Kepler's Third Law, the orbital period T (in seconds) of two bodies orbiting each other in a circular or elliptic orbit is

$$T = 2\pi\sqrt{\frac{a^3}{\mu}}$$

where:

- a is the orbit's semi-major axis in meters
- $\mu = GM$ is the standard gravitational parameter in m^3/s^2
    - G is the gravitational constant,
    - M is the mass of the more massive body.

For all ellipses with a given semi-major axis the orbital period is the same, regardless of eccentricity.

Inversely, for calculating the distance where a body has to orbit in order to pulse a given orbital period:

$$a = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$$

where:

- a is the orbit's semi-major axis in meters,
- G is the gravitational constant,
- M is the mass of the more massive body,
- T is the orbital period in seconds.

orbital velocity

Orbital Velocity Formula
Objects that travel in uniform circular motion around the Earth are said to be "in orbit". The velocity of this orbit depends on the distance from the object to the center of the Earth. The velocity has to be just right, so that the distance to the center of the Earth is always the same.The orbital velocity formula contains a constant, G, which is called the "universal gravitational constant". Its value is = 6.673×10^{-11} N m^2/kg^2 .The radius of the Earth is 6.38×10^6 m.

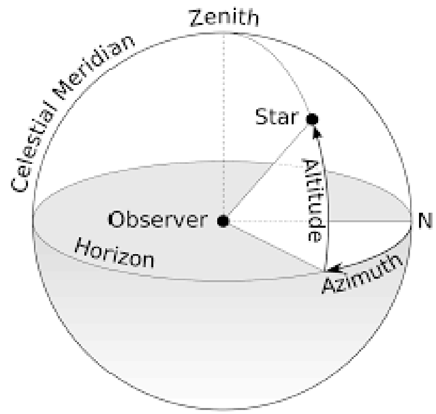
$$\text{orbitalvelocity} = \sqrt{\frac{(\text{gravitational constant})(\text{mass of earth})}{\text{distance from object to center of the Earth}}}$$

$$v = \sqrt{\frac{Gm_E}{r}}$$

v = the orbital velocity of an object (m/s)
G = the universal gravitational constant, G = $6.673\text{x}10^{(-11)}$ N m^2/kg^2
m_E = the mass of the Earth (5.98×10^{24} kg)
r = the distance from the object to the center of the Earth

azimuth and elevation.
Azimuth and elevation are angles used to define the apparent position of an object in the sky, relative to a specific observation point. The observer is usually (but not necessarily) located on the earth's surface
The azimuth (az) angle is the compass bearing, relative to true (geographic) north, of a point on the horizon directly beneath an observed object. The horizon is defined as a huge, imaginary circle centered on the

zenith). As seen from above the observer, compass bearings are measured clockwise in degrees from north. Azimuth angles can thus range from 0 degrees (north) through 90 (east), 180 (south), 270 (west), and up to 360 (north again).



The elevation (el) angle, also called the altitude, of an observed object is determined by first finding the compass bearing on the horizon relative to true north, and then measuring the angle between that point and the object, from the reference frame of the observer. Elevation angles for objects above the horizon range from 0 (on the horizon) up to 90 degrees (at the zenith). Sometimes the range of the elevation coordinate is extended downward from the horizon to -90 degrees (the nadir). This is useful when the observer is located at some distance above the surface, such as in an aircraft.